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July 6, 2004

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

BY HAND DELIVERY
Ms. Marlene Dortch
Secretary
Federal Communications Commission
445 12th Street, SW
Washington, DC 20008

Attention: Chief, Office of Engineering and Technology

Re: Request for Waiver of Sections 15.509 and 205 of the Commission's Rules

Madame Secretary:

Robert Peterson, dba Wavebounce, in conjunction with the GPR Service Providers Coalition, hereby petitions the Commission pursuant to Section 1.3 of the Commission's rules for a limited waiver of certain provisions of Part 15 applicable to a unique category of Ground Penetrating Radar ("GPR") devices. As will be set forth below, the waiver will permit the manufacture and sale of a limited number of non-contact horn antenna GPR devices which are essential to assessing the safety and reliability of railroad beds, highways, airport runways, bridges and similar transportation surfaces.

BACKGROUND

Ground Penetrating Radar ("GPR") is an ultra-wideband technology that has been in use for more than 30 years by the Department of Defense, numerous government agencies, and private industry for a wide variety of public safety and defense-related applications. The technology was originally developed as a means of detecting land mines and underground tunnels in combat environments and in locating ground water. The usefulness of such systems in detecting other underground hazards and conditions immediately became apparent, and in the intervening decades the technology has become an integral and vital part of surveying subsurface conditions for engineering, geotechnical, environmental, and other public safety and scientific applications.

Wavebounce, based in Houston, TX, is a manufacturer of GPR equipment. As will be shown below, the rules adopted by the Commission in 2002 effectively eviscerate the ability of certain GPR devices to be used for pavement, railroad bed, and bridge deck surveying, a development which will, in the near future, seriously compromise the ability of highway departments, railroads, and airports to maintain the basic safety of the surfaces which they administer.

GPR devices can be divided into two broad categories, ground coupled and non-contact horn antenna. Ground coupled devices operate manually somewhat like a lawn mower or vacuum cleaner. The device is held by the operator and the scanned ground surface is literally centimeters away from the device itself, a circumstance that reduces both unintentional radiation to the side of the device and the receipt of unintended signals by the device from extraneous sources. Such a hand-held device, while extremely useful for surveying indoor surfaces, construction sites and other smaller scale targets, cannot effectively be used to test broad or lengthy surfaces such as highways, railroad beds, or runways. For those conditions, a non-contact horn antenna GPR device must be employed. It is these non-contact devices which are the subject of this request.

Because they must survey subsurface conditions over distances of many miles, non-contact GPRs are pulled along behind vehicles which travel at relatively high speeds. In order to avoid damage to the device from bumps, curbs and other road conditions while moving, these GPRs must be, like the undercarriage of a normal automotive vehicle, at least 12 inches above the road surface. To avoid traffic disruption and to reduce the risk of accidents, they are drawn along the surface at normal traffic speeds, and data regarding the roadbed beneath is recorded precisely. Review of the resulting data can establish quickly and economically the subsurface road structure, and pinpoint where this structure is flawed, undermined, or otherwise hazardous. The safety implications of this process are obvious. In airport applications, the use of GPR has ensured that underlying runway defects do not cause aircraft to crater into unseen potholes. The efficiency of the non-contact antenna has allowed this work to be carried out with minimum impact on airport operations and safety. For ordinary highway testing, GPRs eliminate the need to block entire lanes of traffic for hours or days in order to permit laborious testing by outdated mechanical boring methods. The need to apply these latter methods is not only hazardous to the road crews who have to work on the surface adjacent to traffic flow, but creates hazards to the traffic itself. Non-contact GPRs have also been mounted on railcars to inspect railroad beds in order to detect invisible water penetration under the tracks, a condition that has caused several major rail accidents.

The speed and utility of GPR technology has repeatedly detected subsurface hazards that would otherwise never have been discovered in time to prevent dangerous conditions from developing. The use of the technology on bridges is especially important since these structures are particularly susceptible to subsurface deterioration, and any lane closings for testing are extremely disruptive to traffic. Similar considerations apply to tunnels, where speedy testing is critical to safety and traffic flow.

Non-contact GPRs operating near the normal speed limit over road surfaces also serve a very practical function. When highway surveys are performed at low speeds, the manpower required to accomplish the survey multiplies several fold. Instead of a single crew operating in one or two vehicles, many additional large vehicles must be deployed around the surveying operation to shield it from the nearby traffic flow. The survey itself can take as much as ten times longer since the speed at which the pavement can be examined is severely reduced. The result is that a survey which could be conducted quickly and relatively inexpensively becomes, instead, a significant budget item involving a commitment of major manpower and monetary resources by the transportation entity. As an unfortunate practical consequence, surveys of subsurface conditions in bridges and tunnels will be done far less frequently -- or not at all -- if they must be done at low speed.

At least ten different state highway systems and the Federal Highway Administration use GPR extensively to test highway pavements for underlying defects which would not otherwise be readily detectable. The American Association of State Highway Transportation Officials (AASHTO) formally requested the Commission as far back as the spring of 2002 to modify Part 15 in order to permit continued use of GPRs for this highway work. (Attachment A) As reflected in the attached Department of Transportation flyer, the U.S. DOT has also strongly touted the benefits of GPR use for highway safety. (Attachment B) DOT, through the Federal Railroad Administration, is also encouraging the use of GPRs as a promising method of surveying railroad beds. See attached Research Results report. (Attachment C) GPR technology has been extensively applied to testing of commercial and military airfield pavements, both by the USAF and by numerous consulting companies. NASA itself uses GPRs before every shuttle landing to ensure the safety of the landing surface. In short, non-contact GPRs are an important tool used extensively by state and federal governments to preserve the safety of the nations transportation networks.

REGULATORY DEVELOPMENTS

In 1998, the Commission initiated a rulemaking proceeding to examine the use of UltraWideBand technology, including GPR devices. It quickly became apparent in the course of the rulemaking proceeding that GPRs, because they radiate a relatively low level of energy directly into the surfaces which they are examining, pose no threat to other users of the electromagnetic spectrum, including GPS units. Indeed, it became clear that many GPR users actually position GPS devices directly above or adjacent to the GPR operating device to ensure a precise determination of the location of the subsurface condition being studied. In the thirty-some years of GPR use, there have been no instances of interference to other spectrum users. The Commission accordingly "grandfathered" the GPR devices which were already out in the field, provided they were properly registered and coordinated. *Waiver Order* in ET Docket 98-153, 17 FCC Rcd 13522 (2002). This Order was critical to the transportation testing community because it permitted the important work which can only be conducted by non-contact GPRs to continue. Given the number of invisible flaws in roadbeds, rail lines, and runways which have been detected by these grandfathered devices over the last two years, we have no hesitation in asserting that lives have been saved by the continued availability of this equipment.

The grandfathered devices had been operating for many years without mishap at power levels higher then those now authorized. Nothing in the record of ET Docket 98-153 suggested a basis for reducing these power levels, nor was there any evidence of a problem which needed to be fixed by a reduction in power. Nevertheless, apparently reacting to concerns expressed by the National Telecommunications and Information Administration, the Commission imposed extremely severe limitations on the output power of new GPR devices operating above 960 MHz. On reconsideration, in its final *Memorandum and Order and Further Notice of Proposed Rulemaking,*[1] the Commission declined to lift these power restrictions.

THE PRESENT PROBLEM

As explained above, the process of testing roadways, runways, and railbeds requires by its nature that the testing devices travel swiftly over the surface to be examined and must be far enough above the surface to prevent damage to the device from bumps and protrusions over which the device passes. These conditions present three distinct and grave challenges to the effectiveness of non-contact GPRs. First, because they must be 12 inches above the ground, the received signal at the unit suffers from increased separation and reflection losses going into and out of the ground. The received signal is therefore much weaker than that received by a handheld GPR operating at equal power. Second, because the device is a foot above surface level, it is susceptible to noise from extraneous sources. Such received signals are obviously extremely weak under these conditions, but because the intended receipts from the ground are themselves extraordinarily weak, the data obtained can become confused or useless. Third, given the high speed at which the device is moving, the output data rate (PRF) must be relatively high in order to represent signal variations over a large amount of surface per unit time. Since data rate is closely related to output (and, hence, received) power, the extremely low emission levels for GPRs contained in the rules make non-contact GPR impractical for the very purposes for which it is ideally suited and intended.

Tests show that at a power level only 6 dB below Part 15.209 levels, ambient noise causes noticeably increased amplitude variations in GPR output. Received pulse amplitudes are typically the primary data of interest because they indicate the electrical properties of the paving layers and their interfaces. Thus, noise-like variations of only a few percent can produce useless radar output. Even in cases where absolute amplitude information is less important (for example, in determining the thickness of pavement layers), the ambient noise can actually mask the very weak returns from the deeper layer interfaces. In short, operation at the emission levels prescribed by the new rules renders non-contact GPRs operating in the 1 Ghz band useless for their intended purpose, and Wavebounce has therefore chosen not to produce such a device.

[1] *Revision of Part 15 of the Rules Regarding Ultra-Wideband Transmission Systems*, 18 FCC Rcd 3857 (2003).

To circumvent these issues, Wavebounce examined the possibility of manufacturing a non-contact device using spectrum above 3.1 GHz where emissions at normal Part 15 levels are permissible. Wavebounce designed and assembled a prototype pulse radar device which would operate at those frequencies. Laboratory and field tests proved disappointing. Although several inches of homogenous brick material could be inspected, signal levels from even thin (2 - 3 in. thick) asphalt or concrete pavements were so low as to be useless. Analysis showed that the primary problem was scattering from the aggregate materials in the pavement. The size of the rocks in the pavement approach the wavelengths of the pulse and they therefore act as powerful scatterers which cause very high attenuation. The device therefore had to be abandoned.

At the same time, operation at frequencies below 960 MHz is not an option. At these frequencies the distance resolution, which is proportional to wavelength, becomes too poor to identify the separation of the layers in typical paving material. Since layer separation is one of the key interpretive tools for locating potential flaws in subsurface materials, the loss of this functionality destroys the utility of the process. Moreover, the much larger antenna which would be required for this frequency would make the device impractical for most current applications. The plain upshot of these experiments is that GPRs with a center frequency near 1 GHz provide the perfect balance between the signal penetration and the distance resolution necessary to survey railway beds or pavements composed of aggregates.

The GPR Service Providers, an independent group of firms and entities who employ GPR technology for surface testing, can verify that their limited experience with non-contact GPR devices operating in compliance with the new rules has been disappointing. Not only do they have very high noise levels which render the data virtually useless, but they can only be operated at speeds of a few miles an hour, thus creating the very traffic hazards to the public and to work crews which the technology is designed to avoid. The GPR Service Providers do survey work for many state and local highway systems; they contract with airports to perform surveys of runways; they examine railroad beds for rail companies. The Service Providers are extremely concerned that as the existing fleet of grandfathered equipment reaches the end of its useful life, there will be no new generation of non-contact GPR devices to take its place. There is literally no substitute either presently available or on the developmental horizon which can do the job adequately while complying with the new GPR rules.

Wavebounce has received requests from at least ten different prospective users, including state transportation departments and private surveyors who contract with state governments, who need functional non-contact GPR systems to accomplish their testing. None of these request can be satisfied because, under the present constraints, Wavebounce cannot deliver a useful non-contact horn antenna device. The Texas Department of Transportation, which has a particularly vast land area to administer, has offered its strong support for this waiver request in Attachment D.

PROPOSED SOLUTION

Because the problem identified above affects only a relatively small subset of the GPR universe, which is itself a tiny fraction of the larger UWB field, the situation seems most amenable to a waiver of the rules. Wavebounce and the GPR Service Providers request that Part 15 be waived to permit Wavebounce to manufacture and sell non-contact horn antenna GPR devices subject to the following provisos:

1. The equipment would comply with the emission levels prescribed by Section 15.209 of the rules and could operate in the frequency band above 960, subject to all other UWB requirements.

2. Use of the devices would cease immediately upon notification that any interference was being caused by the GPR to GPS instruments, air traffic navigation, control or communications transmissions, or to any licensed operator.

3. A maximum of 25 units per year would be manufactured for use and sale in the United States and its territories.

4. All users of the equipment would be required to register the equipment in a manner similar to that applicable to the presently grandfathered GPR equipment, as well as current Section 15.525.

5. The devices would not be used within 500 meters of a major airport without advance coordination with the airport.

This proposal serves the important function of permitting the current fleet of non-contact GPR devices to be replaced as it wears out or becomes obsolete. The Commission has already recognized in granting the 2002 waiver that these units provide a service which is critical to public transportation safety. *Waiver Order, supra*. Unless the present waiver is granted, that public safety function will suffer a grave impairment. Wavebounce also believes that there will be some increase in usage by the railroad industry which has increasingly become aware of the importance of detecting subsurface defects in their railroad beds *before* derailments occur rather than during post-accident investigations. There is no substitute technology which railroads can use for this purpose. Indeed, the public interest benefits of the proposed usage in terms of public safety and the integrity of the nation's transportation system are so overwhelming that they cannot be exaggerated.

At the same time, the proposed waiver will do no violence to the Commission's rules. The Commission is already aware that the grandfathered GPR devices operating precisely as requested here have created no problem whatsoever to anyone. There is every reason to believe that the newly manufactured devices will have the same record of non-interference as the older models. Moreover, because only a handful of these devices will be manufactured, the chances of any interference are negligible. We would expect, for example, that there would never be more than fifteen of these devices operating in the entire state of Texas; rarely would they be operating at the same time or in the same geographic area. In many states, we estimate that there would be a maximum of one device operating in any given *week*. There will therefore never be any clustering or aggregation of units which might heighten the interference potential.

Moreover, to allay any concerns which the FAA might have about interference to airport signals, we have proposed a healthy safety zone around any larger airport[2] which far exceeds the worst case 126 meter distance at which a GPR device operating at full Part 15 power levels could even be detected by an ideal noiseless GPS receiver. Under real world conditions, the distance at which a GPR signal of this kind could create any adverse effect would be far less -- as real world experience confirms. Given the enormous public interest benefits on the one hand and the absence of any downside interference potential on the other, the case for waiver of the rules is clear.

Section 1.3 of the rules has been interpreted to require a showing consistent with the criteria of Section 1.925 of the rules[3] and the teachings of the Court of Appeals in *WAIT Radio v. FCC*, 418 F.2d 1153 (D.C. Cir.1969). "The agency's discretion to proceed in difficult areas through general rules is intimately linked to the existence of a safety valve procedure for consideration of an application for exemption based on special circumstances."[4] Because sound enforcement must allow for "more effective implementation of overall policy," among other factors, "[t]he limited safety valve [of a waiver] permits a more rigorous adherence to an effective regulation."[5]

A waiver proponent must show either that application of the rule would not serve its underlying purpose or that, in view of unique or unusual factual circumstances, application of the rule would be inequitable, unduly burdensome, or contrary to the public interest, or that the applicant has no reasonable alternative. *Duluth PCS, Inc., supra*. The most apt decision path here is a demonstration that strict application of the rule to this category of GPR devices would not only be contrary to the public interest, but that GPR manufacturers have no alternative under the rules to provide the subsurface surveying capability which is crucial to their mission. As we have seen, GPRs serve a unique and critical role in ensuring the integrity of the transportation infrastructure. Wavebounce and others have determined that because of the peculiar characteristics of the substances to be examined and the conditions under which they must be examined (*i.e.*, at a high speed), it is necessary to use the 1 GHz frequency band. In addition, because of the height above ground of the devices when operated, they must be operated at a power level sufficiently high to permit the receipt of intelligible and useful data uncorrupted by noise. Normal Part 15 emission levels are adequate for this purpose. Operation at these

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[2] We have assumed that smaller community airports without sophisticated radio systems would have no need for protection.

[3] *Duluth PCS, Inc. and St. Joseph PCS, Inc.*, DA 04-1075, rel. April 26, 2004.

[4] *Id.*, 418 F.2 at 1157 (citations omitted).

[5] *Id.*, 418 F.2 at 1159 (citation footnote omitted).

frequencies at those power levels would permit the devices to carry out their intended functions. *Elastic Networks Petition for Waiver of Signal Power Limitations*, 16 FCC Rcd 13974 (2001).

There is no reason to believe, based on thirty years of experience with the grandfathered fleet of GPRs, that there will be any likelihood of interference to any other spectrum user. However, in order to forestall any such possibility, Wavebounce has proposed a set of conditions which ensure that no interference will be experienced by any one. The number of devices to be manufactured is highly circumscribed, thus ensuring that they will never operate in sufficient numbers to create any possibility of power aggregation. In addition, the very nature of the pavement surveying work ensures that the devices will normally be spread out over large areas. Finally, we have proposed a special restriction on operation around airports to ensure that there can be no unforeseen consequences to air traffic communications. All of these elements provide strong assurances that the underlying purpose of the rule -- avoidance of interference to other users -- will be respected.

CONCLUSION

For the reasons set forth above, therefore, Wavebounce and the GPR Service Providers Coalition request grant by the Commission of the waiver requested. Because of the safety implications of the testing for which these devices are used, prompt action by the Commission is respectfully requested.

GPR Service Providers Coalition
Wavebounce

By Donald J. Evans
Donald J. Evans

Their Attorney

DJE:deb

cc: Edmond Thomas, OET
Julius Knapp, OET
John Reed, OET
Alan Scrime, OET
Karen Rackley, OET
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AMERICAN ASSOCIA[T
AND TRANSPOR[T

COMMITTEE CORRESPONDENCE

Address Reply to

May 15, 2003

Mr. Michael K. Powell
Chairman, Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Dear Mr. Powell:

As chairman of AASHTO's Technology Implementation Group (TIG), I would like to provide additional information and support for the attached AASHTO request that the Federal Communication Commission (FCC) and the National Telecommunications and Information Administration (NTIA) reconsider the new emission requirements (FCC 02-48) for ultra-wide band devices.

The TIG selects new technologies for national implementation based on two predominant factors: that the functionality of the technology has been well-demonstrated in the field, and that high value should be realized by nationwide implementation by AASHTO member departments. Ground Penetrating Radar (GPR) strongly meets these two criteria, as further described below. GPR is one of only six technologies to have been selected by the TIG since the group's inception over two years ago.

Current Field Use of Ground Penetrating Radar

GPR has been used by a number of member departments, including Texas, Florida, Minnesota and Utah. It is used for a variety of important purposes, but most notably to evaluate pavements and their foundations. The Texas Department of Transportation, who own and routinely operate several GPR units, considers GPR to be a standard pavement evaluation tool. A frequent application for the equipment is to analyze pavements prior to reconstruction to determine if deeper, undetected base problems exist. GPR is also used to accurately and quickly determine many miles of pavement layer thicknesses, as the equipment is usually mounted on a van and operated at highway speed. It has been used to find unmarked graves within the highway right-of-way, and natural sink holes and other voids under pavements.

Value of Ground Penetrating Radar Use

Lives may well have been saved recently when a water line under IH 35 in Austin, Texas was found to be leaking. GPR was brought in to determine the extent of voids that likely had been created under the roadway. Based on surprising GPR results, traffic was immediately removed. The pavement collapsed under its own weight within a few hours.

The quality of engineering decisions can be significantly improved when GPR data is available, as use of GPR provides continuous measurements along a roadway. As an example, an $8 million Houston pavement project was reduced in cost to $6 million when full-depth repairs were found unnecessary in many places by GPR test equipment. Texas has estimated that use of GPR equipment can be expected to save them more than $50 million over the next ten years in this type of application.

Since GPR testing is typically performed at highway speed, a lane does not have to be closed for testing purposes. This not only eliminates a traffic disruption, but it greatly improves safety for both the traveling public and the technicians performing the testing.

In conclusion, the AASHTO TIG believes that the proven value of GPR warrants strong consideration and use by all AASHTO member departments. FCC and NTIA reconsideration and relief from current GPR equipment acquisition restrictions will be necessary for this to occur. This reconsideration and relief is respectfully requested.

Sincerely,

Gary L. Hoffman

Gary L. Hoffman, P.E., Chair
AASHTO Technology Implementation Group

April 30, 2003

Mr. Michael K. Powell
Chairman, Federal Communications Commission
445 12th Street, SW
Washington, DC 20554

Subject: Request for Relief for Ground Penetrating Radar (GPR) Equipment
Reference: FCC Revision of Part 15; DA02-1658; ET Docket No. 98-153

Dear Mr. Powell:

AASHTO is requesting that the Federal Communication Commission (FCC) and the National Telecommunications and Information Administration (NTIA) reconsider the new emission requirements (FCC 02-48) for ultra-wide band devices. The new FCC order is too restrictive. Although all existing GPR systems had an opportunity to be registered, the new order does not allow DOT's to purchase new systems and maintain existing systems unless they are certified. The order does not even recognize DOT's as authorized users of the technology. AASHTO urges the FCC and NTIA to revert to the previous specifications. Please see the following position statement on the subject matter:

Continued Use of Ground Penetrating Radar for Transportation Uses

The American Association of State Highway and Transportation Officials (AASHTO) is a nonprofit, nonpartisan association representing highway and transportation departments in the 50 states, the District of Columbia and Puerto Rico. It represents all five-transportation modes: air, highways, public transportation, rail and water. Its primary goal is to foster the development, operation and maintenance of an integrated national transportation system.

Recently the AASHTO Technical Implementation Group (TIG) selected ground-penetrating radar (GPR) as an innovative technology to showcase, fund and implement throughout the AASHTO membership. AASHTO believes that GPR is a critical technology that will assist DOT's with the management of their transportation networks. This belief is based on documented routine use experiences from states such as Texas, Florida, Minnesota, and Utah. AASHTO believes that the use of GPR will allow the State DOT's to allocate funds and improve safety for the traveling public and DOT work crews. The use of GPR in the area of public safety has been well documented by locating the size and extent of washouts and sinkholes beneath highways.

The GPR is a non-destructive, non-invasive instrument that allows the user to determine all types of anomalies beneath the surface. The GPR is a cost-effective tool that minimizes user costs by allowing DOT's to concentrate on localized areas for repair work. GRP systems are tuned to operate at specific central frequencies. This means that the user must have several GPR units available depending on the depth and size of the defect being detected.

GPR has been used to evaluate airport runways without disruption of the airport facility; it has been used by the American military and is used in a growing number of foreign countries. To limit its use in the USA would only limit innovation and productivity in America while allowing other nationalities to continue development and implementation.

The Ground Penetrating Radar energy is directed downward into the pavement surface and is therefore classed as an unintentional radiator. The GPR has been used in conjunction with global positioning systems (GPS) and cell phones for the last 5 to 10 years with no reported incidence of interference. GPR's have been in and around airports for the last 10 to 15 years with no reported incidence of interference or concerns for safety.

Based on the above background position the American Association of State Highways and Transportation Officials Request Relief for Ground Penetrating Radar (GPR) Equipment as referenced in FCC Revision of Part 15; DA02-1658; ET Docket No. 98-153.

Sincerely,

John Horsley
Executive Director

Enclosure

cc: Graham Hill

KK:mav

Attachment B

U.S. Department of Transportation
Federal Highway Administration

Priority, Market-Ready Technologies and Innovations

Ground-Penetrating Radar

Problem: Highway pavement assessment generates significant maintenance costs

A significant portion of the cost of maintaining the highway system goes to determining the remaining service life of pavements and highway structures such as bridge decks. One of the greatest challenges in rehabilitating pavements is determining what is causing them to deteriorate and selecting the most appropriate rehabilitation measures.

How are pavements tested?
Traditionally, highway engineers have used such techniques as drilling core samples out of the pavement to establish layer thickness and determine what conditions beneath the road surface are causing it to deteriorate.

What are the disadvantages?
Conventional processes for taking core samples are labor intensive, require lane closures, and create potential safety hazards for highway workers and the traveling public. Extracting pavement cores and analyzing them at an offsite laboratory can be time consuming and expensive.

Solution: Ground-Penetrating Radar surveys pavements quickly and inexpensively

Using ground-penetrating radar (GPR) technology, highway engineers can assess subsurface conditions at a fraction of the cost of conventional methods. GPR systems survey pavements quickly and with minimal traffic disruption and safety risks.

What is GPR?
GPR technology is a field survey method that creates a cross-sectional image of the pavement subsurface. It is a pulse-echo technique for measuring pavement layer thickness and other properties, such as moisture content.

In a GPR system, antennas mounted on a moving vehicle transmit short pulses of radio wave energy into the pavement. As this energy travels through the pavement structure, echoes are created at boundaries of dissimilar materials, such as at an asphalt-base interface. The strength of these echoes and the time it takes them to travel through the pavement can be used to calculate pavement layer thickness and other properties.

Why use GPR?
GPR surveys can be conducted anywhere. The survey equipment is mounted on a vehicle that can travel at normal highway speeds, so lane closures are not required, traffic is not interrupted, and highway workers are not exposed to safety hazards. The equipment is compact and easily transportable.

GPR has a variety of applications, including assessing freeze-thaw damage, evaluating deterioration, measuring overlay thickness, and maintaining quality control of steel reinforcing bar placement.

Successful Applications: States use GPR to survey pavements and bridge decks

The Strategic Highway Research Program, Federal Highway Administration (FHWA), and several State departments of transportation (DOT) have conducted studies demonstrating the advantages of using GPR technology. Several States-including Florida, Louisiana, Michigan, North Carolina, and Texas-use GPR in their pavement evaluation programs.

The Florida DOT acquired a GPR system to gather data on pavement layer thickness and base layer material properties for its pavement management inventory. The system can collect data at a rate of more than 322 kilometers (200 miles) per day.

The Arizona DOT used GPR to survey 135 bridge decks as part of a bridge inspection program. The project provided data on deck conditions and steel reinforcing bar depths on more than 0.139 million square meters (1.5 million square feet) of bridge deck. Results were available quickly and at an affordable cost. GPR allowed the State to test as many as 12 bridges a day without lane closures, traffic disruptions, or exposure of highway workers to safety hazards.

Benefits

- Rapid, nondestructive, cost-effective survey method.
- Real-time data collection.
- Numerous areas of application.

Additional Resources

More information on GPR, including a presentation on implementing a GPR program, is available at www.aashtotig.org/focus_technologies/gpr/.

For more information, contact:

Mike Murphy, Texas DOT
E-mail: mmurphy@dot.state.tx.us

FHWA-HRT-04-072
HRTS-03/01-04(1M)E

Attachment C

U.S. Department
Of Transportation

Federal Railroad
Administration

Research Results

RR02-03
September 2002

Ground Penetrating Radar for Railway Track Substructure Investigation

SUMMARY

The Federal Railroad Administration (FRA) Office of Research and Development's Track and Structures Program sponsored a study for evaluating railway track conditions. Ground Penetrating Radar (GPR) can provide a rapid, non-destructive measurement technique for evaluating railway track substructure integrity. This is being proven in an ongoing study to develop GPR for defining the condition of the railway substructure. Examples of the results of the GPR project to date are shown in Figures 1 & 2. The scan in Figure 1 shows the varying thicknesses of ballast and subballast which, in this example, is an indication of a problem associated with lateral subballast spreading on top of a clay subgrade. The scan in Figure 2 shows ballast pockets that have developed under the track. GPR provides continuous top-of-rail measurements of substructure layer conditions, with the potential to measure the layer thickness, water content, and density of the substructure components (ballast, subballast, subgrade). GPR is also capable of observing trapped water from poor drainage, soft subgrade from high water content, and is potentially capable of distinguishing fouled ballast from clean ballast. The study concluded that GPR images can give a good indication of the subsurface layer configuration and patterns within the data can give a good indication of subsurface condition.

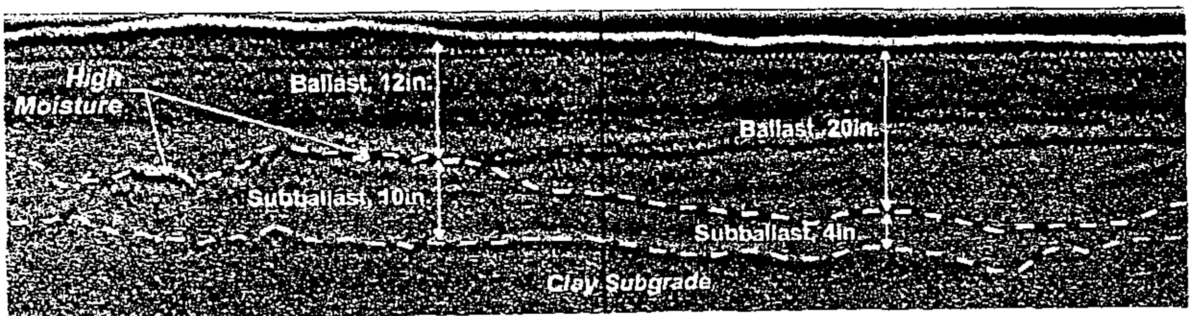

Figure 1. Example GPR Results of Spreading Subballast

Figure 2. Example GPR Results of Ballast Pocket

BACKGROUND

The goal of the study has been to develop GPR procedures for determining track substructure conditions such as layer thicknesses and wet spots. So far, two phases of the project have been completed. Phase 1 of the GPR study consisted of an initial series of laboratory and field measurements, and Phase 2 focused on improving the radar equipment and techniques and demonstrating the benefit of obtaining measurements at multiple positions across the track.

Field Measurements

More than ten (10) miles of track were surveyed at Burlington Northern and Santa Fe Railway's Butte Subdivision, using GSSI 4208 1-GHz air-launched horn antennas. The data were acquired and processed from a hi-rail vehicle moving continuously at 10 miles per hour with radar resolution of a few inches horizontally and a fraction of an inch vertically to depths of more than six feet. The antennas were mounted on a standard hi-rail vehicle 19 to 22 inches above the ties in several configurations as shown on Figure 3.

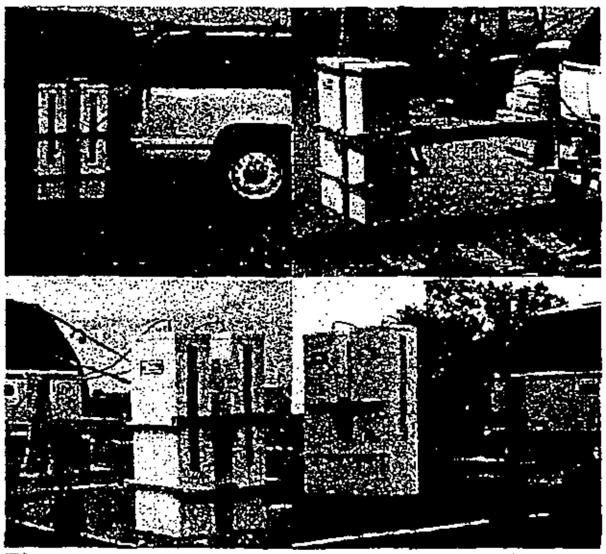

Figure 3. Various GPR configurations on hi-rail vehicles

Typically measurements were made along the track at the ends of the ties and at the track centerline, one location per pass. In this study, radar data were acquired between concrete and wood ties as well as from the ballast shoulders beyond the ends of the ties, and with multiple antenna orientations and polarizations. Data acquisition was controlled by the GRORADAR™ software (Olhoeft, 1998).

Data Processing

Procedures were developed to expedite and simplify radar data processing. Data were calibrated to the recorded time and amplitude (range gain information) and GPR scan images were expanded and contracted (rubber-sheeted) as necessary to match marked locations along the track. The GPR wave velocity was initially calibrated from subsurface reflectors, and later tied to known depths from inspection cross-trenches dug under the tracks in order to get accurate subsurface layer thicknesses and depths. Automatic processing of the data was developed to quickly generate electronic bitmap images and hard copy sections of radar images. The electronic images were put into railroad track performance monitoring software called Optram Right-of-way Infrastructure Management (ORIM) system. Figure 4 shows a screen-grab of the ORIM viewer with the GPR scan aligned with the layout of the track, vertical profile geometry and remedial work locations.

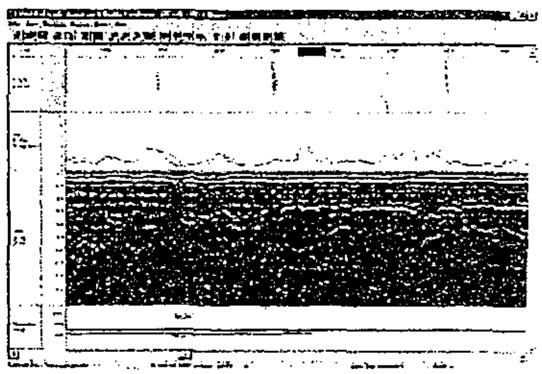

Figure 4. ORIM screen-grab example.

ORIM permitted viewing and correlating the GPR data with railroad information such as track geometry measurements, maintenance input and known subsurface conditions. This allowed for seeing relationship of GPR to track condition and features, as well as visualizing substructure effect on geometry trends and maintenance effort.

To improve the images of the cross sections for observing features of interest, data scans were extracted for modeling. An average background scan was subtracted (to remove constant range scattering mostly from the rails) and image enhancement was applied to the data.

Hardcopy sections of the radar data were produced at 300 feet traverse per 8.5x11 inch sheet for viewing, and files were output in one-mile sections for entry into the ORIM system.

Modeling Method

The GPR data have been modeled using simulated radar pulses that are matched to measured radar pulse to extract material dielectric constants. Water content and unit weight were calculated using relationships with the dielectric constant. This modeling was done on unprocessed data so as not to include the distortion inherent in the data from the processing technique. To verify and calibrate the railway GPR data, it was necessary to dig periodic trenches in locations with key substructure conditions that could be correlated with the radar data. This required real-time data processing into images to locate suitable places to trench. Depths to key substructure layers were then measured in the trenches and used with travel times from the radar data to determine average velocities and convert to dielectric permittivity assuming the magnetic properties of free space. The first air-ballast interface was then calibrated for absolute amplitude from this data and successively deeper reflectors were solved.

RESULTS

The two scans in Figure 5 are from the same track location, the top scan being the north side of the track and the bottom scan the south side. The sand zone (shown in the top scan) acts as a water pocket. The trapped water in this pocket softens the surrounding clay subgrade, causing track geometry deterioration. The "shear key" in the bottom scan was a previous attempt to drain the sand zone by digging a trench and filling it with ballast. The extent of the shear key is well defined in Figure 5.

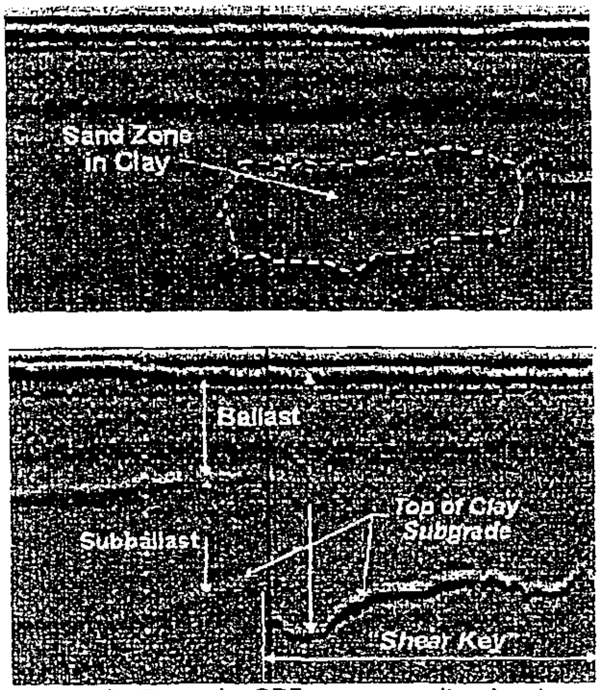

Figure 5. Example GPR scan results showing sand pocket and shear key.

Figure 6 shows a typical example of the subsurface conditions at highway-grade crossings, as detected by GPR. Trapped water immediately adjacent to the crossing is apparent. The decrease in GPR reflection amplitude progressing away from the crossing indicates decreasing moisture content of the subballast and subgrade.

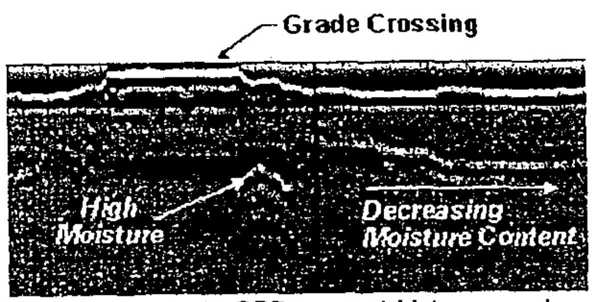

Figure 6: Example GPR scan at highway-grade crossing.

CONCLUSIONS

GPR images can give a good indication of the subsurface layer configuration. Patterns within the data can give a good indication of subsurface condition. GPR is also potentially capable of distinguishing fouled ballast from clean ballast.

GPR provides continuous top-of-rail measurements of substructure layer conditions, with the potential to measure:

- Substructure layer thicknesses,
- Water content and density of the ballast, subballast, subgrade,
- Trapped water from poor drainage,
- Soft subgrade from high water content, and
- Non-uniform and deformed substructure layers and variations in substructure conditions across the track (through multiple passes of a single antenna-pair or with multiple antenna-pairs).

FURTHER WORK

The objective of continued research is to initiate the development GPR measurement and analysis techniques, and to obtain substructure condition indices using GPR. The automated measurement and analysis techniques will be used to produce quantitative indices of track substructure condition that will enable improved cost effectiveness of maintenance planning, increased safety, and reduced train service interruptions. Follow-on work will focus on developing a robust GPR system for use on a hi-rail vehicle or a track geometry car. Further work will continue to develop modeling methods, and automate both the calibration and modeling processes. Additional GPR field measurements, combined with substructure investigations, will also be conducted to improve procedures for interpreting radar data under track, and extend the variety of subsurface conditions tested to improve the generality of the techniques.

ACKNOWLEDGMENTS

This study was performed by Ernest T. Selig, Inc. in collaboration with Dr. Gary R. Olhoeft, Consultant, Golden CO. The Burlington Northern and Santa Fe Railway, through Robert J. Boileau, AVP, supported most of the GPR data collection and much of the interpretation. Mahmood Fateh, from the FRA, provided support for data analysis. The GPR equipment used for the measurements was from Geo-Recovery Systems, Inc. Optram, Inc. provided the ORIM system for displaying the GPR results.

REFERENCES

Olhoeft, G. R., 1998, GRORADAR™: Acquisition, processing, modeling, and display of ground penetrating radar data: ver. 4.0, *7th International Conference On Ground Penetrating Radar*, May 27-30, 1998.

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KEYWORDS: ground penetrating radar, GPR, track substructure, railroad investigation

Attachment D

Texas Department of Transportation

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July 2, 2004

Ms. Marlene Dortch
Secretary
Federal Communications Commission
445 12th St. SW
Washington, DC 20554

Attention: Chief, Office of Engineering and Technology

RE: Support from the Texas Department of Transportation for Request for Waiver of Sections 15.509 and 205 of the Commission's Rules submitted by Robert Peterson, dba Wavebounce, et al.

Madame Secretary:

The Texas Department of Transportation (TxDOT) hereby expresses its strong support for the attached petition for waiver of the Federal Communications Commission (FCC) rules as they apply to certain ground penetrating radar (GPR) devices. We have found that GPR technology, especially non-contact horn antenna GPR technology, to be extremely useful in discharging our responsibility of ensuring the safety of the people of Texas. We have used this technology for over 10 years and it has proven to be a safe, economical, fast and accurate means of determining whether subsurface conditions in roadbeds exist which require immediate or long-range attention. It is critical in this connection that the GPR devices be capable of surveying the pavement structure in question at the posted speed limit. This feature is essential because it permits us to conduct GPR surveys without closing off lanes of traffic. High-speed GPR surveys lessen the safety hazard to work crews and the traveling public as well as reducing the required manpower and costs which such closings entail. In addition, we can survey far larger stretches of highway and do so more frequently than would be possible without this technology.

One very dramatic case in point occurred on I-35 in downtown Austin, Texas during the afternoon rush hour. A water main broke beneath the outside lane. We dispatched a GPR system to survey the subsurface damage. The GPR data showed us immediately that the base and part of the sub-base had been washed away and that a huge cavern had formed beneath the pavement's surface. The lane was closed to traffic immediately. Within one hour of the lane closure, the pavement caved in forming a hole large enough to hold a school bus. Needless to say, without the use of GPR technology this situation could have caused extreme danger to the driving public. There are numerous, less dramatic but dangerous examples of the inherent values of using GPR technology within the state of Texas, namely the location and extent of sink holes.

Equipment grandfathered under the FCC's July 2002 waiver order has served us well. However, new equipment which is presently available and compliant with the FCC's 2002 UWB rules, has been found to be largely ineffective at highway speeds. Not only are we unable to expand our existing small fleet of non-contact horn antenna GPRs, but we will also be unable to replace this equipment in the future as it reaches the end of its useful life. TxDOT is trying to expand its use of non-contact GPR by purchasing and implementing 12 more units. The addition of these 12 units to our current GPR antenna systems will ensure that the entire state of Texas (over 180,000 lane miles) can be covered within a few hours notice. This will permit us to prevent on a much wider scale the kind of hazard which I noted above. By waiving its rules in the case of non-contact horn antenna GPRs, the Commission can ensure that the critical job of ensuring the safety of our highways continues. Absent such a waiver, the condition of our highways can be expected to deteriorate, with attendant danger to life and property as well as increased user cost.

For the above cited reasons, on behalf of the Texas Department of Transportation, I respectfully urge the FCC to grant the captioned waiver. The waiver, if granted, will assist the State of Texas and this agency in fulfilling its mission to provide safe public roads for its citizens and visitors; whereas, lives would be endangered without the ability to use the subject GPR equipment.

Sincerely,

Steven E. Simmons, P.E.
Deputy Executive Director